JOURNAL OF ECONOMIC BIOLOGY.

ON SOME COCCIDAE AFFECTING RUBBER TREES IN CEYLON, WITH DESCRIPTIONS OF NEW SPECIES.

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WITH PLATES I AND II.

THE various species of rubber-yielding trees appear to be self-protected from most biting insects by the action of the viscid latex that exudes from the slightest wound. The secretion is not present in any large quantity in the foliage, and consequently we find the leaves occasionally attacked by caterpillars. The larvae of a Pyralid moth (*Caprinia conchylalis*) have given considerable trouble by repeatedly defoliating our trees of *Funtumia elastica*. But no serious caterpillar pests have yet been recorded from our more important rubber plants (*Hevea brasiliensis* and *Manihot glaziovii*).

Sucking insects, such as *Coccidae*, on the other hand, are able to obtain nourishment from any part of the tree without becoming involved in the exudation of viscid latex. Their sucking tubes (haustella) are so fine and hair-like and are, moreover, introduced so gently and gradually, that they do not cause any wound. They are probably able to avoid the lacticiferous vessels and to extract the sap alone.

In a previous number of this Journal, 1910 (vol. v, part i), I have described a species of *Asterolecanium* that infests Hevea rubber trees in the Seychelle Islands. The following species of *Coccidae* have been observed upon rubber-bearing trees in Ceylon.

On *Hevea brasiliensis*:—

Lecanium nigrum, Nietner: affecting the leaves and young stems. Although sometimes fairly abundant, this species does little or no harm to well established trees. When present on the green stems of young plants and saplings, the insect checks the growth to a certain extent; but on such small plants the pest may be easily removed, either by hand, or by the application of one of the standard soapy insecticides.

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Aspidiotus cyanophylli, Sign.

Mytilaspis fasciata, Green.

These two Diaspid scales may be found upon the foliage; but they do not occur in sufficient abundance to appreciably affect the health of the plant.

On *Manihot glaziovii*:—

Lecanium nigrum, Nietner: affecting the foliage of older trees, but doing little damage.

Dactylopius virgatus, Cockerell. This omnivorous species is sometimes present in considerable numbers on the young foliage and tender stems of the plants. It is fortunately kept in check by several small Coccinellid beetles.

On *Castilloa elastica*:—

Inglisia castilloae, Green. Massed on the leading shoots, main branches and prominent veins of the leaves. The origin of this hitherto-undescribed species is obscure. It suddenly appeared in a small clearing of eight-year-old Castilloa trees, and rapidly spread until every individual tree was almost smothered by the insects. From this centre, it showed signs of extending on to the neighbouring vegetation, and had established itself firmly upon some tea plants in the immediate vicinity. Fortunately, the pest showed no inclination to attack the Hevea trees, some of which were growing so close to the infested Castilloas that their branches intermingled. It was remarkable that, in spite of the heavy infestation, the trees were still growing vigorously, though they had an unhealthy appearance, due—principally—to the dense coating of sooty fungus which covered every leaf. As the pest appeared to be confined to this one small spot, it was thought advisable to exterminate it by cutting down the whole, clearing and burning the trees *in situ*. The species is infested by a minute Chalcid parasite (*Coccophagus orientalis,* Howard).

Dactylopius crotonis, Green. Infesting the younger branches; but apparently doing little injury. The species is partly kept in check by the carnivorous larva of a Lycaenid butterfly (*Spalgis epius,* Westwood).

Dactylopius virgatus, Ckll. On young branches and foliage.

Dactylopius citri, Risso. Occasionally infesting the young shoots.

Aspidiotus camelliae, Sign. Occurring sparsely on the younger branches and foliage.

On *Landolphia* sp.:—

Tachardia albizziae, Green. A vine of this plant (species undetermined) was found to be thickly encrusted by this "lac insect." The Landolphia rubbers are not cultivated in Ceylon: otherwise this insect might prove to be a serious pest. It is parasitized by numerous Chalcids, and is extensively preyed upon by the larvae of a moth (*Eublemma amabilis,* Moore).

Descriptions of New Species.

Inglisia castilloae, n.sp.

Pl. i, figs. 1-21.

Test of adult female (figs. 1 to 4) strongly convex: bilobed, the lobes laterally divergent, forming two irregular confluent cones (fig. 1) between the apices of which is a deep furrow (fig. 4). Viewed from in front (fig. 1) or from behind (fig. 2), the base is narrowed, the sides sloping steeply outwards to the apex of each cone, which is slightly incurved. From the side (fig. 3) the base is broadest, the anterior margins sloping evenly to the apex of each cone, the posterior margin at first rising perpendicularly in a sharp keel as far as the anal aperture, where it divides and runs (with a slightly concave contour) to each apex. Viewed from above (fig. 4) there is a deep transverse furrow extending downwards from the apex of each cone: it is bordered in front and behind by rounded lips, which are medially impressed in the direction of the main axis of the body. The intricacies of form are difficult to describe lucidly, and may be more easily understood by reference to the figures. Each cone is fluted vertically and finely striate transversely. Colour dull brown to reddish ochreous. Proportionate dimensions very variable, dependent upon the angle of the divergent cones: average length at base, 3.50 mm.

The adult female insect, which is of a reddish brown colour, more or less fills the test before oviposition, but becomes shrunken afterwards. Viewed from the side (fig. 5), the dorsum is seen to rise steeply into two obtuse points with a shallow transverse cavity between them. An irregularly tubercular carina runs from the posterior edge of this cavity to the anal operculum, below which the margin is deeply cleft. There are small indentations at the stigmatic areas, and a complete marginal fringe (fig. 6) consisting of a somewhat irregular row of stout, sharply pointed conical spines, with a series of pores below them. These pores are in the form of small pits with chitinous walls, and some of them appear to be compound.

There are no specialized stigmatic spines, but the marginal spines are rather more crowded at the stigmatic areas. The anal aperture (fig. 7) is surrounded by a hoop of dense chitin enclosing the valves of the anal operculum which are of very irregular outline, the apices tuberculate and bearing several stout spine-like hairs. The anal ring carries six long stout hairs. A median dorsal series of small pores extends upwards from the anal operculum. Antenna (fig. 8) with seven joints, of which the third is the largest: a stout curved hair on inner side of 4th, 5th, and 6th, joints, and several on the side and apex of the 7th. In some examples there is a partial division of the 3rd joint, cutting off a narrow terminal chitinous ring. Legs small but well formed, claw moderate, tarsal digitules long and slender, ungual digitules somewhat broadly spatulate (fig. 9). Spiracles large and conspicuous, rather densely chitinous. Length of base 2.50 to 3.50 mm.

The newly-hatched larva is dark red, of the normal, flattish, elongate-oval form, with a marginal fringe of stout glassy filaments, supported by a series of stout conical spines, set at some distance from each other; stigmatic areas each with a single longer pointed spine; antennae rather short, 6-jointed; legs usually short and stout. Anal ring with 6 hairs. Caudal setae about half length of body. Length approximately 0.75 mm.

Subsequent growth is first in the direction of a prominent hump on the dorsum of the thorax, and is shortly followed by a second, but smaller prominence on the dorsum or the abdomen (fig. 10). This contour is masked by the two lateral glassy plates which meet along the median longitudinal line, forming an irregular cone with a flattened top (fig. 11).

Further development of the test is shown in figures 12 to 15. A median longitudinal sulca first appears (fig. 12). This gradually widens and reveals a deeper transverse median sulca. This transverse furrow lengthens (figs. 13, 14) and becomes proportionately narrower until it assumes the form (fig. 16) that persists in the fully developed insect. Arrival at the adult stage is signified by the presence of seven joints in the antennae.

The male larvae develop somewhat differently. The dorsum does not become so elevated; it is covered by a single elongate conical plate, and the margin has a fringe of flattened glassy points, which finally coalesce to form the series of conical plates found in the male puparium.

The male puparium (fig. 17) is elongate oval, with a prominent conical glassy plate covering the dorsum, and a smaller triangular

plate—with a central elongate boss above the posterior extremity. There is a marginal series of seven more or less conical plates, of which one is at the anterior extremity and three on each side, their cusps directed slightly upwards and forwards. All the plates with radiating striae. Length approximately 2 mm.

Adult male (fig. 18) bright red, head and terminal half of abdomen darker. Costal nervure of wings purplish crimson, the colour extending to the costa on the terminal half. Ocelli black, 4 on upper and 4 on lower surface of head (fig. 19), the median pair of each set larger. Rudimentary eyes black, small but prominent, situated immediately behind the outer pair of dorsal ocelli. Antennae not quite so long as body, 10-jointed; first two joints stout and short, others elongate and narrow, clothed with moderately short curved hairs; two longer knobbed hairs at apex of terminal segment. Notal plates of thorax ill-defined. Scutellum broadly rounded. Lateral margins of abdomen roundly carinate. Genital sheath long, straight, sharply pointed, rather more than half length of abdomen (in fresh and extended examples). A pair of very long, white slender waxy caudal filaments, supported by setae springing from a glandular pit on each side (fig. 20). A short, fleshy process on each side of terminal segment. Wings ample, minutely pubescent, extending beyond extremity of genital sheath. Halteres apparently wanting. Legs long and slender. Total length (including genital sheath) 1.6 mm.

Insects thickly encrusting the branches, twigs and undersurface of leaves of *Castilloa elastica* (fig. 21). Koslanda, Ceylon, July, 1910. Occurring also upon the following plants in the immediate vicinity:—*Grewia microcos, Adenochlaena zeylanica, Solanum* sp., *Vernonia* sp., and Tea.

The species is parasitized by a minute Chalcid recognized by Dr. L. O. Howard as *Coccophagus orientalis,* How.

Superficially, *I. castilloae* somewhat resembles *fossilis,* Mask., but may be readily separated from that species by the presence of well-developed limbs. Its peculiar form distinguishes it sufficiently from all other known members of the genus.

Mytilaspis fasciata, n.sp.

Pl. ii, figs. 22, 23.

Female puparium (fig. 22) pale translucent yellow, sometimes, with a greenish tinge; exuviae ochreous, the larval pellicle, with the anterior and posterior extremities dark, reddish brown, the nymphal pellicle with a reddish-brown longitudinal median fascia

(sometimes broken into two or more spots), and a similarly coloured rounded patch covering the pygidial area. Elongate, narrow, widening slightly behind the nymphal pellicle; sides sub-parallel; margin flattened. Length averaging 2.50 mm. Breadth 0.5 to 0.75 mm.

Male puparium not known.

Adult female very pale yellow; pygidium reddish. Anterior extremity truncate, the lateral angles tuberculate. Rudimentary antennae each with two rather long stout bristles. Pygidium (fig. 23) broadly rounded, the extremity slightly truncate; median lobes conspicuous, floreate, somewhat widely separate, with a median pointed process between them; first lateral lobes small, narrow, duplex; other lobes obsolete. There is a prominent marginal process between the median and lateral lobes, bearing a large oval pore; similar pore-bearing processes occur at intervals on each side beyond the lobes. Squames spiniform, tubular, in groups of 2 or 3. Anal aperture near base of pygidium. Circumgenital pores in five small groups, median group of 3 to 4 pores, anterior laterals 6, posterior laterals 4. A few large and conspicuous dorsal oval pores on pygidium, and numerous smaller pores on margin of abdomen. Length, 0.75 to 1 mm.

Heneratgoda, Ceylon.

Scattered on undersurfaces of leaves of *Hevea brasiliensis*; usually lying along one of the veins.

A typical *Mytilaspis*, of the *pomorum* and *citricola* group; but well characterized by the colour pattern of the puparium.

Tachardia albizziae, n.sp.

Pl. ii, figs. 24-33.

Adult female concealed within a more or less globular case of resin, of a colour varying from bright fulvous to dark castaneous; the colour frequently obscured by a deposit of sooty fungus. The insects are usually so crowded together that the resinous tests become agglomerated and their normal shape is obscured. Each test has three small circular elevated apertures, arranged in a triangle (see fig. 24, which represents two confluent individuals). The aperture, which is at the apex of the triangle, is the hindermost, and represents the anal orifice; it is usually more prominent and larger than the other two. The remaining pair of apertures admit air to the spiracles; they are distinguished as the stigmatic orifices, and are sometimes scarcely raised above the surface. During the life of the

insect, tufts of opaque, white, waxy filaments project from each aperture, preventing the ingress of water, while admitting the free passage of air. A shallow rounded carina extends forwards from the base of the anal orifice to a little beyond the stigmatic orifices. The surface of the test may be either smooth or irregularly rugulose or tuberculose. The resinous substance is hard, but brittle, and is readily soluble in alcohol. A single isolated test has a diameter of approximately 3 mm.

A median longitudinal section of the test (fig. 25) reveals the body of the insect occupying the anterior half of the cavity, with the abdominal segments retracted. It is normally of a uniform, rich crimson colour; but there is a variety that is of a bright gamboge-yellow colour, in all stages. Both forms often occur together on the same twig. Before gestation, the insect completely fills the cell. As oviposition proceeds, the body shrinks, and the resulting cavity is closely packed with ova, the young larvae making their exit through the posterior aperture of the test.

The fully extended insect (fig. 26, antero-dorsal view) is roughly cordate in form, with a prominent caudal extension, at the extremity of which is the anus. The dorsal area forms a broadly rounded prominence demarked by a shallow groove from the remainder of the body. The ventro-lateral areas are roundly produced on each side. The stigmatic tubercles are comparatively small, and are situated towards the posterior extremity of the dorsum. At the base of the caudal extension, situated dorsally, is a prominent fleshy tubercle, which bears at its apex a stout, pointed tubular chitinous spine. The rostral filaments proceed from between two small fleshy lobes on the ventral surface of the body. Each stigmatic tubercle is mammiform (fig. 27), and has a central pit-like depression, in which are numerous glandular pores arranged more or less in rosette-shaped clusters, with a larger pore occupying the centre of each cluster. An irregular chain of small pores connects the glandular pit with the large dorsal spiracle, which is situated at the base of each stigmatic tubercle. A second pair of small spiracles opens on the venter, close to the rostrum. The caudal extremity is partially surrounded by a deeply and irregularly toothed fringe, incomplete on the ventral margin. The anal orifice is protuberant, and is encircled by a chitinous ring, composed of six distinct plates, which support ten stout hairs, the lateral plate on each side bearing a single hair, the other eight plates having two hairs apiece. Round the base of each hair is a group of glandular pores. In the adult insect the whole organ is so densely chitinous that these details are more or less obscured, and the chitinous plates often appear to be confluent;

but the structure can be made out more distinctly in the nymphal insect in which the plates are distinctly isolated (fig. 28).

Immediately above the caudal extension is the remarkable spine that occurs in most species of *Tachardia*, the function of which still remains a mystery. That it has some definite use is evident from its connection with numerous elongate pyriform gland cells, disposed either singly or in small groups (fig. 29), which communicate by thread-like ducts with the tubular spine. In the present species, the spine is placed upon a small, stout fleshy tubercle, the extremity of which is surrounded by a rim with a tooth-like prominence on the upper border. The spine itself is slightly curved, stout at the base and tapering to a point, bluntly toothed towards the base of the ventral surface.

The diameter of the adult insect ranges from 2.25 to 2.50 mm.

Male puparium (fig. 30) oblong, slightly broader towards the anterior extremity, with a more or less distinct carina and a well-defined oval valve at the posterior extremity; colour dark brown; surface finely rugulose; length approximately, 1.50 mm.

There are both winged and apterous forms of the adult male. They are both of a rich crimson colour, with a pair of long, opaque white filaments from the caudal extremity. In the winged form the antennae are 10-jointed, and the notal plates are more or less distinct; the wing has a pinkish costal nervure. In the apterous form the antennae have 9 joints only, and the thorax remains soft and undeveloped. The terminal joint of the antenna (in both forms) bears two knobbed hairs at its apex. There are four prominent black ocelli on the head, 2 on the upper and 2 on the under surface. The genital sheath is elongate, slender, and sharply pointed, rather more than half as long as the abdomen. The total length of the insect (inclusive of genital spike) is approximately 1 mm.

Nymphal test of female (fig. 31) symmetrically 6-lobed; dorsal area with a median longitudinal rounded carina, terminating behind at the large anal orifice. Stigmatic orifices situated on the anterior half of the test, above the junction of the first and second lateral lobes. There is a prominent beak-like point above the anterior extremity.

Young nymph (fig. 32) obscurely lobed; both pairs of spiracles situated dorsally, the anterior pair larger; caudal extremity (fig. 28) similar to that of the adult, but with the anal ring more distinctly broken up into isolated plates.

Encrusting the young stems of *Landolphia*, sp. Peradeniya, Ceylon, April, 1910. Occurs also on *Albizzia stipulata*, *Filicium*

decipiens, Harpullia cupanioides, Theobroma cacao, Sleichera trijuga, Croton lacciferum, and other trees.

Although the name of this insect has appeared in print on several occasions, it has hitherto been a "*nomen nudum.*" No previous description of the species has been published.

Dactylopius crotonis, n sp.

Pl. ii, figs 34-37.

Adult female (fig. 34) broadly ovoid, strongly convex above. Colour, brownish red, disguised by a more or less complete coating of white, mealy powder, which is more thickly disposed on circular patches (10 to 12) on the thorax, and transversely on the abdominal segments. In the early adult (shortly after ecdysis) these white areas stand out conspicuously against the darker ground colour; but in the older individuals these specialized areas may be obscured by a more general covering of the white secretion. Margin, with short, stout bluntly-pointed waxy processes, subequal in length. Antenna (fig. 35) 8-jointed; the 8th longest, longer than 6th and 7th together, with a median clearer area suggestive of a suppressed division; all the joints, with a few stout hairs, springing more particularly from the apical half; antennal formula (exclusive of 1st joint)--1, (6, 7), (2, 3), (4, 5). Legs well developed, robust; claws stout, curved; digitules hair-like, the unguals dilated at extremity, the tarsals not appreciably dilated. Mentum dimerous. Eyes broadly oval, colourless, with slight central granulation; situated just outside the base of each antenna. Posterior extremity (fig. 36) with a rounded lobe (not very prominent, except in parasitized examples) on each side, from which springs a long, stout seta, a longish stout bristle, several short fine hairs, and two acutely-pointed conical spines. A similar pair of pointed spines at intervals along the margin of the body, 17 pairs on each side (inclusive of those on the posterior lobes). Between the terminal lobes are two pairs of stout bristles. Anal ring with six longish stout hairs. Derm with numerous small and inconspicuous subtriangular pores, and sparsely scattered fine hairs, which are longer and stouter on the interantennal space. Some larger circular ceriferous pores on the venter surrounding the genital orifice. A pair of transversely elongate glandular cicatrices near the front of the dorsum, and a second pair near the posterior extremity (at the junction of the antepenultimate with the previous segment). Length (of compressed mounted examples) 2.25 to 2.50 mm. Breadth, 1.75 to 2 mm.

The insects are very frequently parasitized by a small Dipteron which pupates within the body of its host. Parasitized examples (fig. 37) are much swollen, the body of the Coccid being distended by the pupa of the fly. In such individuals, the posterior tubercles and the tuberculate margins of the abdominal segments are very prominent.

The insect makes no definite ovisac, but is ovo-viviparous.

On *Castilloa elastica.* Massed upon the young shoots and smaller branches, and sometimes upon the prominent midrib on the undersurface of the leaves. Not secreting much waxy matter, so that each individual in the mass can be easily distinguished.

Occurs also on the variegated Croton (*Codiaeum variegatum*), on *Terminalia catappa, Erythrina lithosperma,* and many other trees and shrubs.

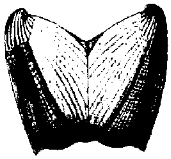
EXPLANATION OF PLATES I AND II.

Illustrating Mr. E. Ernest Green's paper "On some Coccidae affecting Rubber Trees in Ceylon."

Plate I.

Inglisia castilloae.

Fig. 1.—Test of adult female, front view, × 8.
Fig. 2.— ,, back view, × 8.
Fig. 3.— ,, side view, × 8.
Fig. 4.— ,, from above, × 8.
Fig. 5.—Adult female insect (removed from test), side view, × 10.
Fig. 6.—Marginal spines and pores, × 450.
Fig. 7.—Anal orifice, × 100.
Fig. 8.—Antenna, × 250.
Fig. 9.—Foot, × 450.
Fig. 10.—Early larva (removed from test), side view, × 20.
Fig. 11.—Test of early larva, from above, × 20.
Figs. 12 to 15.—Stages in the development of larval test, × 20. (All viewed from above, with the exception of 15, which represents a side view of 14).
Fig. 16.—Older larva (or nymph), from above, × 10.
Fig. 17.—Male puparium, from above, × 16.
Fig. 18.—Adult male, dorsal view, × 16.
Fig. 19.—Head of male, side view, × 25.
Fig. 20.—Abdominal extremity of male, from below, × 55.
Fig. 21.—Twig of *Castilloa,* with insects *in situ,* nat. size.



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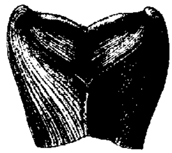

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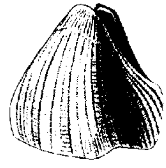
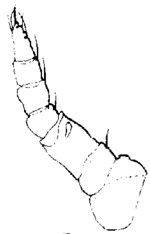


3 × 8.

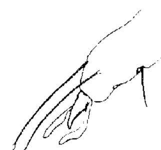
7 × 100



8 × 250

10 × 20.

11 × 20



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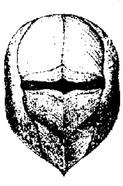
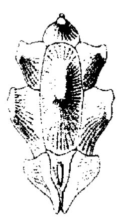
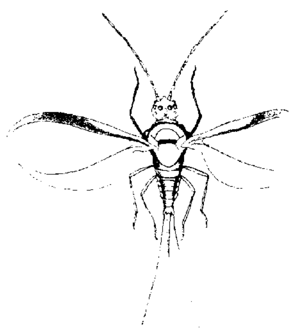


16 × 10.

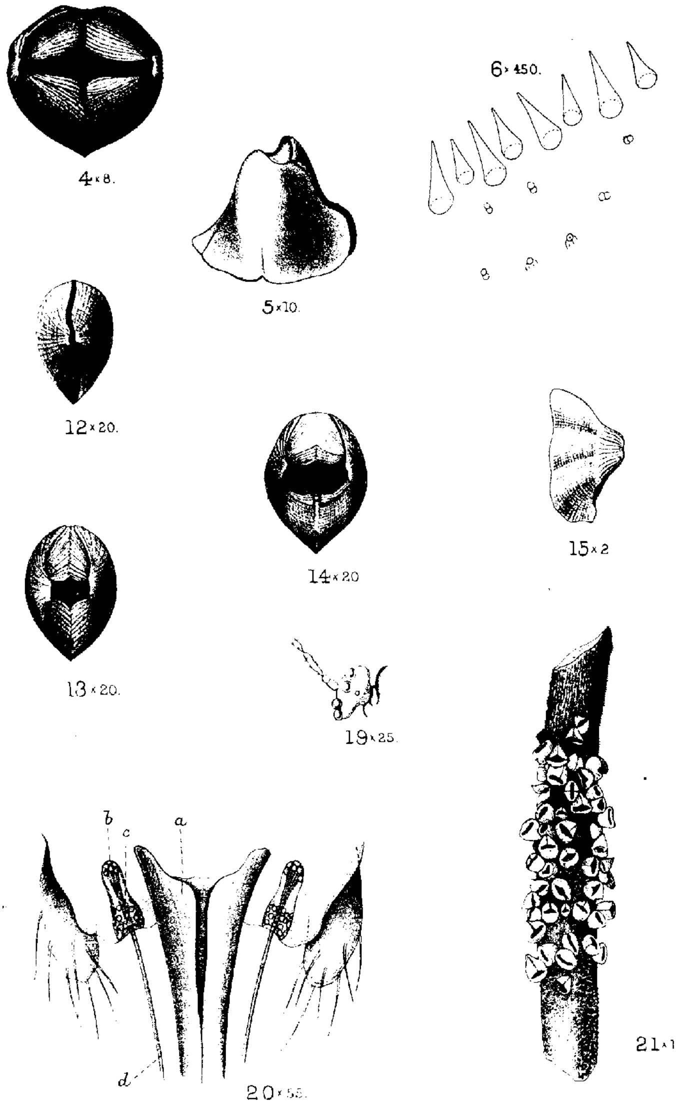


17 × 10.

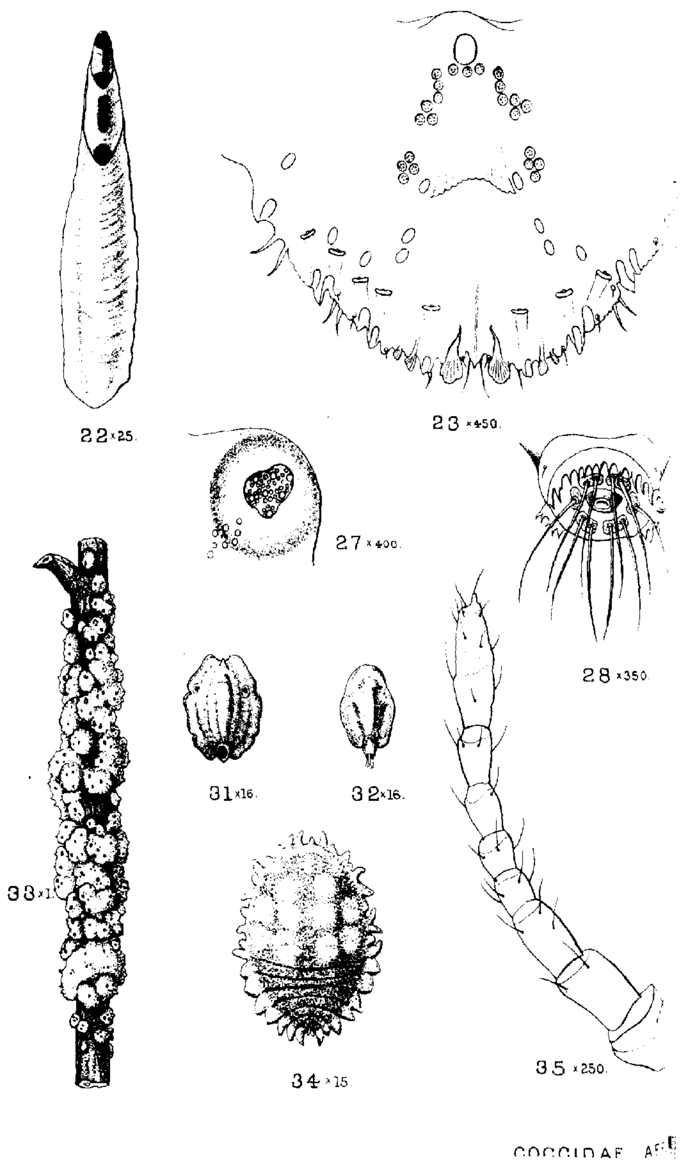


18 × 16.

Pl. I.



Huth Lith^rs London



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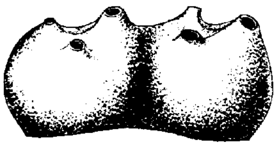
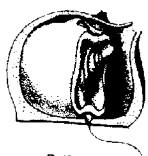
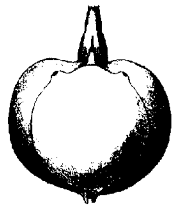


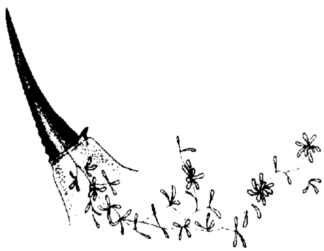
24 ×8



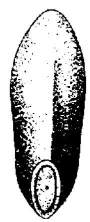
25 ×8.



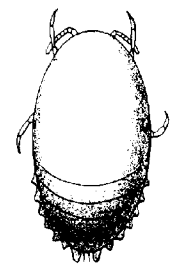
26 ×16



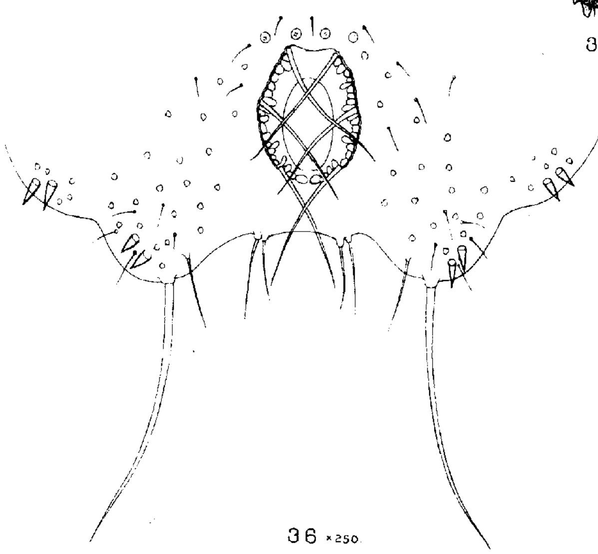
29 ×400



30 ×25.



37 ×15.



36 ×250

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PLATE II.

Mytilaspis fasciata.

Fig. 22.—Puparium of female, dorsal view, × 25.
Fig. 23.—Pygidium of adult female, optional section, × 450.

Tachardia albizziae.

Fig. 24.—Two confluent tests of adult female, side view, × 8.
Fig. 25.—Median longitudinal section of single test, × 8.
Fig. 26.—Adult female, anterodorsal view, × 16.
Fig. 27.—Dorsal stigmatic tubercle, × 400.
Fig. 28.—Anal extremity of female nymph, × 350.
Fig. 29.—Dorsal spine of adult female, × 400.
Fig. 30.—Puparium of male, × 25.
Fig. 31.—Test of female nymph, × 16.
Fig. 32.—Female nymph, removed from test, × 16.
Fig. 33.—Insects, *in situ*, on stem of *Landolphia*, nat. size.

Dactylopius crotonis.

Fig. 34.—Adult female, dorsal view, × 15.
Fig. 35.—Antenna, × 250.
Fig. 36.—Posterior extremity (optional section), × 250.
Fig. 37.—Parasitized female, dorsal view, × 15.

FOUR LITTLE-KNOWN BRITISH FUNGI.

By

W. B. GROVE, M.A.,

WITH PLATES III AND IV, AND I TEXT-FIGURE.

THE four Fungi which are described in the present communication have been under cultivation for a considerable time in the Botanical Laboratory of the Birmingham University. Three of them belong to the group which is often falsely called *Fungi Imperfecti*—falsely, because it is by no means true that all of them are now, whatever they may have been in their origin, mere conidial forms of more highly evolved species. The other is a species of *Mucor*, which seems to be of rare occurrence in Britain. Each of them presents several points of interest, especially from a systematic point of view.

Mucor spinosus, Van T.

Pl. iii, figs. 1-9.

Mucor spinosus, Van Tieghem, Ann. Sci. Nat., 1876, iv, p. 390. Bainier, *ibid.*, 1884, xix, pl. 7, figs. 1-8. Gayon, Mem. Soc. Phys. Bordeaux, 1878, sér. 2, ii, figs. 10-12. Sacc. Syll. Fung., 1888, vii, pt. i, p. 191. Fischer, Phycomycetes, 1892, p. 203, fig. 30 *e*. Trans. Brit. Myc. Soc., 1900-1, i, 193. Klocker, Fermentation Organisms, 1903, p. 183, fig. 60 (spores incorrectly drawn). *M. aspergilloides*, Zopf.

Sporangiophore about $\frac{1}{2}$ cm. high, erect, soon branched: branches sometimes erect and as long as, or longer than, the main hypha, sometimes very short, and patent or faintly recurved, with a septum usually above the insertion of each branch, colourless and granular, each branch ending in a sporangium. Sporangia all of one kind, but differing much in size, round, up to 80 μ diam., at first opalescent and densely granular, then brownish, and finally dark-brown or (by reflected light) black; membrane finely aculeate, at first tough (fig. 6), at length evanescent except for a basal collar, which is usually patent, but sometimes reflexed. Columella obovate-oblong or pear-shaped, up to 60 × 25 μ (in small lateral sporangia from 16 × 9 μ), furnished towards the top with several (1-15) short, stumpy, inflated or acute, spiny processes of various shapes (figs. 2, 3), sometimes but rarely without any spines; membrane in the case of the larger sporangia distinctly pale-brown. There are occasionally additional septa in the hypha just below the sporange (fig. 5) and even in the columella (fig. 3 *c*). Spores spherical or slightly irregular

(fig. 7) 4-6, or even as much as 8 μ diam., smooth, appearing greyish-brown even when seen singly. Chlamydospores not uncommon in the mycelium (fig. 8), intercalary or terminal, resembling those of *M. racemosus*, but much less numerous. Ferment-cells round (fig. 9), highly refringent. According to Gayon (*l.c.*) they ferment glucose, but not sucrose.

Var. **recurvus**, *m.*

Like the species, except that most of the branches are curved arcuately downwards (fig. 4).

M. spinosus is easily recognised by its spiny columella. Saccardo (*l.c.*) says that the spores are "minutely verrucose." Under a one-tenth immersion they do sometimes appear slightly punctate, but I have never seen them truly rough, and usually they are perfectly spherical and smooth. The chlamydospores of this species are not only much less numerous than those of *M. racemosus*, but also do not possess so thick and lamellated a cell-wall. Not all species of *Mucor* are provided with chlamydospores, which are the exact analogues of the *aplanospores* of the Algae. If Brefeld's genus *Chlamydomucor* is adopted for those which do possess them, it will include *M. spinosus* as well as *M. racemosus*.

The typical form branches both monopodially (fig. 5), and less often sympodially (fig. 1), but the variety *recurvus* seems predominantly sympodial (fig. 4). In this case, the septum which arises in the hypha above the insertion of each branch appears (owing to the sympodial development) to be at the base of the apparent branch.

The variety occurred repeatedly, with the type, in the Brewing Laboratory of the University; pure cultures of it were made by Mr. Compton Till (who first observed it) and by myself. It is probably merely a form, but deserves especial mention, because of its liability to be confounded with *Circinella spinosa* and *Mucor circinelloides*. On comparing fig. 4 with the figures of *C. spinosa* (Van Tieghem, Ann. Sci. Nat., 1873, pl. 22, fig. 46) and of *M. circinelloides* (Bainier, *l.c.*, pl. 7, fig. 11), the close resemblance in habit will be manifest; in fact they could with difficulty be distinguished except for the remarkable columella of the present species. There is, strange to say, however, a fungus described by Schröter (Schles. Krypt. Fl., iii, 1, p. 206), and assigned by Fischer (Phycom., p. 217) to the genus *Circinella* as *C. umbellata*, var. *asperior*, which has the columella provided at the summit with processes exactly similar to those of *M. spinosus*. It seems worthy of consideration whether this was really

not a *Circinella*, but only an unusually developed sympodial form of *M. spinosus*, var. *recurvus*. The description of the spores and many of the details are not inconsistent with this supposition.

Occasionally, again, I have found the main hypha in my cultures producing one, or two very nearly opposite, branches just below the summit, exactly like the figures of *M. bifidus* in Fresenius (Beitr., pl. i, figs. 13, 19-21). Text-figure A shows two of these, one bifid, the other trifid; it is evident that these modes of branching are not peculiar to the *M. bifidus* of Fresenius, and it is in fact possible that the latter is identical with *M. spinosus*. This supposition, at least, seems more probable than Fischer's suggestion (*l.c.*, p. 190) that it is a form of *M. mucedo*; but of course it cannot be entertained unless it is permissible to believe that Fresenius entirely overlooked the spiny processes of the columella. His description of the spores presents equal difficulties under either hypothesis: the columella of *M. spinosus* may occur, very rarely, without the spines.

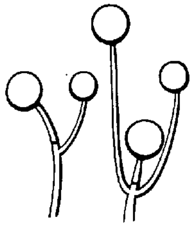

Fig. A.—Showing branches of main hypha.

Rhopalocystis, gen. nov.

Hyphae steriles repentes; fertiles erectae, simplices, apice vesiculoso-inflatae. Conidia basidiis sterigmatophoris suffulta, fusca, sphaeroidea. Est Sterigmatocystis dematiea.

Rhopalocystis nigra.

Pl. iii, figs. 10-16.

Rhopalocystis nigra, m. *Aspergillus niger*, Van Tieghem, Ann. Sci. Nat., 1867, p. 241. Raulin, Ann. Sci. Nat., 1869, pl. vii, fig. 4. Klocker, Fermentation Organisms, 1903, p. 277.

Sterigmatocystis nigra, Van Tieghem, Bull. Soc. Bot. Fr., 1877. Saccardo, Syll. Fung., 1886, iv, p. 75.

Conidiophore erect, eseptate, thick-walled (wall 2 μ thick), cylindrical or nearly so, pale-brown, often nearly hyaline at base, filled with very granular, yellowish-brown protoplasm, $\frac{3}{4}$—$1\frac{1}{2}$ mm. high, 20—25 μ broad, ending in a globose head, which is also thick-walled and of the same colour as the upper part of the hypha, 40—50 μ diam., and finely punctate all over, with the insertions of the basidia (fig. 12). Basidia crowded, radiating, oblong-clavate, 40—70 × 10—12 μ, pale yellowish, each bearing a few (8—10) linear-oblong sterigmata, 10—15 μ long; each sterigma produces basipetally a long chain of spores (fig. 13) Conidia spherical, dark-

brown, nearly black in mass, 4—5 μ diam., at first smooth, at length very delicately verruculose (fig. 15); each conidium is connected with the next by a slender hyaline isthmus, which at length vanishes; isthmus cylindrical or slightly swollen towards the lower end (fig. 14).

The mode of formation of the spores is as follows:—The sterigma ends in an acute point, upon which the last-formed spore is perched. The portion of the sterigma a little distance below this points swells out somewhat, and a constriction is formed below the swelling (fig. 16 *b*). The swelling increases, the constriction becomes narrower, and a fresh spore is thus formed, connected by a narrow isthmus both with the spore above and with the sterigma. No doubt a septum is formed at each end of this isthmus, though it could not be seen in progress. The sterigma (fig. 16 *a*) then enlarges to its former size, and the process is repeated. The membrane of the basidia and of the sterigmata is nearly colourless, but both are filled with a rich yellow protoplasm. The young spore is quite colourless, but soon assumes an olive colour, which gradually deepens until the mature spore is dark-brown.

This species was originally placed by Van Tieghem in the genus *Aspergillus*, but afterwards transferred by him to *Sterigmatocystis*, which differs from *Aspergillus* in having the spores borne on sterigmata, not immediately on the basidia. But it is impossible, so long as the Dematieae are maintained as a distinct group (which must be done, if only for convenience) to leave this species among the Mucedineae, since the colour in mass is distinctly a very dark olivaceous-brown, and by reflected light appears nearly or quite black. All the other species of the same section of *Sterigmatocystis* (Sacc. *l.c.*) should be transferred to *Rhopalocystis*, viz.:—

Rhopalocystis fusca (Bain.)
,, *antacustica* (Cram.)
,, *phaeocephala* (Sacc.)
,, *carbonaria* (Bain.)

The distinction drawn in this case is exactly that which has already been made between *Verticillium* and *Verticicladium*.

There are also dark-coloured species of *Aspergillus*, included in the section "Fuscescentes" (Sacc. Syll. Fung. iv, 70), for which presumably a separate genus should be founded; but, according to the descriptions, none of these belong to *Rhopalocystis*.

Van Tieghem at first did not observe the sterigmata, and described the basidia as simple and measuring 11—16 × 2.5 μ,

but these evidently were immature. Afterwards he discovered his mistake. The young head is covered with smooth, clavate basidia (fig. 11), but before they begin to produce spores the sterigmata arise at their summit, though for the following reason they are often difficult to see. The curious isthmuses which connect the spores with each other and with the sterigmata are ultimately resolved into mucus; this binds the whole mass together so that the spores do not readily separate on the addition of water, as do those of most species of *Aspergillus* and *Penicillium*. On this account a growth of *Rhopalocystis nigra* does not appear pulverulent.

This species occurred on the endosperm of coco-nut (hung out for birds to peck at) at Edgbaston and at Studley Castle; it was also independently found by Dr. Jessie S. Bayliss in a contaminated culture in the Botanical Laboratory. It is the species which has been the subject of many investigations by physiologists. According to Malfitano, Miyoshi, Raulin, Gayon, Bourquelot, and others, it produces many enzymes, such as diastase, maltase, invertase, emulsin, zymase, a protease, etc., and breaks up tannin into gallic acid and glucose. It has been found in the Brewing Laboratory of the University that it can be used as a most convenient source of invertase and emulsin.

Monilia lupuli.

Pl. iv, figs. 1-8.

Monilia lupuli, Mass. in litt. *Oidium lupuli*, Matthews and Lott, The Microscope in the Brewery and Malthouse, 1899, p. 86. Lindner, Atlas der mikroskopischen Grundlagen der Gährungskunde, 1903, pl. 28. Sykes, The Principles and Practice of Brewing, 3rd ed., 1907, p. 290.

Forming an effused farinaceous stratum of a fine pinkish-salmon colour. Conidiophores up to 1 mm. high, erect, slender, septate, branched above; branches rather divaricate; chains of spores also branched in the same manner. Diameter of hyphae about 5 μ; conidia roundish or oval, nearly hyaline (singly), 7—9 × 4 μ.

Communicated by Professor Adrian Brown. Occasionally met with in breweries, on the surface of spent hops, lying in heaps exposed to the air. It looks like a salmon-coloured dust; under the microscope the colour is seen to be diffused through the protoplasm. The transition from the ultimate joints of the hyphae to the conidia is often a very gradual one.

The spores of *M. lupuli*, when plasmolysed, show a distinct "*hilum*" or mark indicating the point at which they were attached to one another; all the spores, except the terminal youngest ones, have two or three of these marks. The "hilum" is really a thickened ring of the cell-wall (fig. 4 *c*); seen in full face-view it often

presents an appearance remarkably similar to that of a leaf-scar, with a few darker, thickened, and often protruding portions in the middle of the circle, which might fancifully be supposed to represent the leaf-trace bundles (fig. 4 *a*, *b*).

On germination, in distilled water, the spore swells up, loses its dark outline, and becomes more rounded. It then emits 1, 2, or 3 tubes, at any part of its periphery; these soon begin to branch by similar tubes (fig. 8), and produce a hyaline septate mycelium. A remarkable fact noticed on many occasions is that the branches of the mycelium anastomose freely (figs. 5, 7); even two germ-tubes may anastomose before they have travelled twice the length of the spore (fig. 5).

There were also instances which showed that the anastomosing hyphae were attracted by one another (fig. 6). In fact some such attraction must be manifested in most cases where an H-connection is formed. Instances of a somewhat similar kind are known in connection with filaments concerned in reproductive processes, *e.g.*, in the hyphae which conjugate to form the zygospore of *Mucor mucedo* (Blakeslee, Sex. Reprod. Mucor., p. 274, pl. ii, fig. 30 *c*), and in the production of scalariform conjugation in *Spirogyra*. But in the case of *M. lupili* the phenomenon is distinctly manifested by the purely vegetative hyphae.

The protoplasm of the hyphae was in streaming motion in all the cells; a small agglomeration of it could be observed to move through its own length in less than a minute. The motion was of the kind called *circulation*, the protoplasm passing along the strands from side to side, and perpetually changing the position of the vacuoles. In almost all cases there was a little accumulation of cytoplasm on each side of a septum.

Anastomoses of an exactly similar character are figured by Planchon (Ann. Sci. Nat., 1900, xi, p. 97, figs. 21-2) in his *Alternaria varians*; and by Marshall Ward (Ann. Bot. ii, pl. 22, figs. 27-30) in the ***Polyactis*** which causes a Lily disease; also anastomoses of the hyphae soon after they have issued from a spore are figured by Massee (Text-book of Fungi, fig. 5, 1) in *Trichothecium roseum*, and are compared by him with those which are so pronounced a feature in the germinating secondary spores of the *Ustilagineae*.

Hormodendron, Bon. (1851).

Sterile hyphae creeping; fertile erect, septate, more or less olivaceous, variously branched; chains of conidia at ends of branches; conidia globose, ovoid or oblong, continuous, olivaceous or brown.

Hormodendron cladosporoides.

Pl. iv, figs. 9-15.

Hormodendron cladosporoides, Sacc. Mich. ii, p. 148; Syll. Fung., 1886, iv, p. 310. Lindner, Mikroskopische Betriebskontrolle, 1898, p. 237, fig. 110. Planchon, Ann. Sci. Nat., 1900, xi, p. 155, and figs. 37, 39, 44. Hedgcock Missouri Bot. Gard., Ann. Rep., 1906, xvii, p. 98, pl. 10, fig. 1. Bancroft, Ann. Bot., 1910, xxiv, 359. pl. 24.

Penicillium cladosporoides, Fres. Beitr, 1850, p. 22, pl. iii, figs. 23-8.

Mycelium white or pale-olive, hyphae 3—5 μ diam.; tufts diffused, indeterminate, olivaceous, forming a thin dirty green stratum with a whitish margin. Conidiophores erect, cylindrical, branched above into two or three parts; if the former, the stem is dichotomous; if the latter, the branches are often opposite and decussate, patent or irregular; articulations of branches fusoid, passing gradually into the conidia; chains of conidia two or three together, short, branched, diverging. Conidia ovoid or elliptic, smooth, somewhat apiculate at each end, 6—7 $\times$ 3·5 μ, pale olivaceous; the ultimate conidia are nearly round.

On the cut surface of a vine-stem, Bulkington (Wk.), Mr. Compton Till; also on damp wall paper, Lower Edmonton, Mr. James Scott; and on decaying leaves, Studley Castle.

The spores vary considerably in size and shape; the articulations of the branches are sometimes 1-septate or even 2-septate; and the lower articulations show occasionally indistinct markings, as if they might become polyseptate, though they were never seen to be so in reality. The mode of branching varies also, and often agrees exactly with the figure of Fresenius.

The germination of the spores of *Hormodendron* is as follows: A conidium slightly swells and emits from its surface, at any point, 1, 2, or 3 germ-tubes. If the apparent spore is two-celled (really one of the upper articulations of the branches of the conidiophore), one or both of its cells may "germinate" in a similar way. The tube soon begins to send off branches, mostly at right angles; sometimes the tube remains cylindrical, but at other times it becomes markedly torulose; both forms may issue from the same conidium. In the latter case, the cells are about as long as broad, and in all cases they remain short as compared with the ordinary mycelial cells of the majority of fungi. In most cases all the cells are olive-coloured, though slightly paler than the spore, which remains, for that reason, easily distinguishable so long as the mycelium is not too intricate. H-connections frequently arise between parallel or nearly parallel hyphae, and sometimes but rarely a slight net-work is formed.

Very soon one of the branches of the hyphae assumes the

functions of conidiophore, usually by forming at its summit two buds, which gradually assume a fusoid shape, and produce at their apex two or three similar buds. The latter may become spores or may continue the growth of the hypha. Finally, spores only are produced.

Each bud arises as a circular swelling, connected with its base by a slender tube: the swelling gradually enlarges, and assumes the mature form; then or earlier the tube is closed by a septum. The order of formation is always basifugal, as in *Alternaria*, and is strictly comparable to the budding of *Saccharomyces*. Another bud may arise at the summit or side of one which is still incompletely formed. Now and then two or even three buds may arise from a single cell; in this way branched chains of spores are produced. *The true spores, forming the terminal chains, were never seen to be septate.*

The mode of formation of the spores (basifugal) is the opposite of that shown by *Penicillium glaucum* (basipetal). The former mode produces branched chains, the latter not. This mode of formation is, in general, a generic character. *Hormodendron* should be compared not with *Penicillium*, but with *Monilia*. It is a dematioid *Monilia*.

The distinction between basipetal and basifugal spore-formation has not hitherto been much regarded by systematists, but there is little doubt that it is a constant feature at least in those species which have non-septate conidia, and as such could be used in the generic character. Among the genera which have basifugal spores, like *Hormodendron*, are *Monilia*, *Amblyosporium* and *Alternaria*: while *Penicillium*, *Aspergillus*, *Sterigmatocytis*, and some species of *Torula* have basipetal spores, like *Rhopalocystis*. The aecidiospores of *Puccinia* also are produced basipetally.

Planchon (*l.c.*, p. 155) and Bancroft (*l.c.*, p. 368), as well as others, state that there is no doubt that *H. cladosporoides* is merely a form of the ubiquitous *Cladosporium herbarum*. Even if this is so, it is a form which presents an appearance so different that it must be mentioned and described particularly. Of course, in a sense, their statements may be true, since it is well-known that *C. herbarum* is a collective name, under which numerous forms have been included.

It is possibly true in a wider sense, but can scarcely be considered proved. Though both authors describe and figure branches of their *H. cladosporoides*, in which the passage to a *Cladosporium* type is stated to have occurred, their figures do not bear out their contention. So far as is shown by the cultures (on various forms of nutrient gelatine) made by Mr. Compton Till and myself, the true conidia in

the *terminal* chains of the fungus were never septate; some of the upper joints of the hyphae are (fig. 14), and moreover, as shown in figure 11, these hyphal articulations can put forth tubes and form a mycelium as well as the spores. But that is to be expected in a case like this, where the transition from hyphae to spores is a gradual one. It is just as true of *Monilia lupuli;* there also the upper hyphal joints "germinate" readily, and often produce a better mycelium than the conidia, from which, nevertheless, they are easily distinguishable. When a mycelial cell thickens its walls and becomes an "oidium" (as is frequently the case in the mycelium of Hymenomycetes), this "oidium" can "germinate" exactly like a spore; it is, in fact, the analogue of an Algal *akinete*.

In the true *Cladosporium herbarum,* so far as I have seen it, there is not the same gradual transition from hyphae to conidia, and many unmistakable conidia are two or even three-septate.

Bancroft mentions (p. 368), what is quite true, that, if his view of the relation of the two forms he met with is correct, they must be considered an unusual combination among the Fungi. His further contention, that they constitute a complete life-cycle, is quite unproved; they might, either or both of them, easily be stages of a higher fungus, and yet be capable of continuous propagation in their own forms. There is no intention here of criticising his results, but, judging by his figures, it is still permissible to express the opinion that his "*Cladosporium*" is not *C. herbarum*. It is not sufficient to assume, if a hypha produces a structure like that shown in his figures 7–9, that therefore it is a *Cladosporium* spore, since it has been shown above that many of the hyphal joints of *Hormodendron* are one or more septate. Compare plate ii, fig. 14.

I do not assert that *H. cladosporoides* has not a *Cladosporium* form, but only that its identity with *C. herbarum* has not yet been demonstrated. However, even if it should be proved, the genus *Hormodendron* would still stand, until a similar fact has been shown for the other species assigned to it.

Our cultures have, nevertheless, made it evident that *Hormodendron viride* (Fres.) is only one of the earlier stages of *H. cladosporides*. The gradual change from a form like fig. 16 of Fresenius (*l.c.*) to that of his figure 23 could frequently be traced; also his *nigro-virens* (fig. 22) does not seem to present any essential difference. Whether his *chlorinum*[1] (figs. 20, 21) is different, I cannot tell.

[1] It is, in my opinion, a mistake on the part of Saccardo to consider (Syll. Fung., iv. 311) that Fresenius intended to place his *nigro-virens* as a variety of his *chlorinum*. His words (Beitr. p. 22) do not bear that meaning.

H. elatum, Harz (Hyphom, pl. 5, fig. 6) may well be nothing but a luxuriant state; it does not show any other character that might form a mark of distinction, but I have never seen anything quite so luxuriant as in Harz's figure.

One striking peculiarity of our cultures, on nutrient gelatine, is that the mycelium produces, below the surface, a very thick dark-green or black stratum, which at length wrinkles and contracts from the lower part which has not been penetrated by the mycelium. For this reason, the appearance of a culture changes from olive-green to brownish-green or blackish-green, as it advances. Hence we conclude that the forms mentioned above are probably only growths of *H. cladosporoides* of various ages. Their spores are all nearly identical, or at least come well within the limits observed. *H. olivaceum*, Bon., *H. solani*, Sacc., and *H. herbarum*, Sacc., on the other hand, are distinctly different, and *H. atrum*, Bon., according to the figure and description (Bot. Zeit. 1853, p. 286, pl. vii, fig. 7) looks also different, and does not agree with any stage of the fungus met with in the cultures.

In the 17th Annual Report of the Missouri Botanic Garden, 1906, p. 100, pl. 10, fig. 2, Hedgcock describes and figures a species of Hormodendron, which he names *H. griseum*, and which is evidently closely allied to *H. cladosporoides*. He also states that he grew both species, in a series of parallel cultures, for nearly a year "with no reversion of one type to the other," such as he expected. Nevertheless the only important difference observable was that due to the nearly hyaline mycelium of *H. griseum*, which imparted a grey appearance to the cultures. In his *H. cladosporoides* the mycelium was apparently always coloured. In our cultures both appearances were observed, even from the same spore (fig. 12); and as stated above, the margin of a patch of mycelium was always whitish. The conclusion is that *H. griseum* is only an accidental form of *H. cladosporoides*. It is not uncommon that, of the mycelium and the spores of Dematieae, one should be colourless while the other is olivaceous, *e.g.*, *Stachybotrys dichroa*, *Acrotheca atra*.

Finally I would place *Penicillium chartarum*, Cooke (Handbook, 1871, p. 602, fig. 270), not as is done by Saccardo (Syll. Fung. iv, 305), and following him by Massee (Fung. Fl. iii, 381), in the genus *Haplographium*, but in *Hormodendron*. The original figure of Cooke in Popular Sci. Review (1871), pl. 68, fig. 4, agrees with this determination. In fact, *H. chartarum* is closely allied to *H. cladosporoides*, but probably not identical with it. Cooke's figure shows the branching of the upper part of the hypha, and, roughly

drawn though it is, it seems to be different from anything met with in the latter species.

The species of *Hormodendron* may then be arranged as follows:—

Conidia, oblong, fusiform or elliptic, when fully formed. ...	*H. cladosporoides*, Sacc. (including *H. viride*, Sacc.; *H. nigrovirens*, Sacc.; *H. elatum*, Harz.; *H. griseum*, Hedgcock). *H. chartarum*, m. *H. atrum*, Bon. *H. hordei*, Bruhne, and var. *parvispora*, A. L. Sm. *H. solani*, Sacc.
Conidia, round, when mature. ...	*H. olivaceum*, Bon. *H. herbarum*, Sacc. *H. chlorinum*, Sacc. (possibly).

In conclusion, I have to thank Professor G. S. West for help in connection with this investigation.

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EXPLANATION OF PLATES III. AND IV.

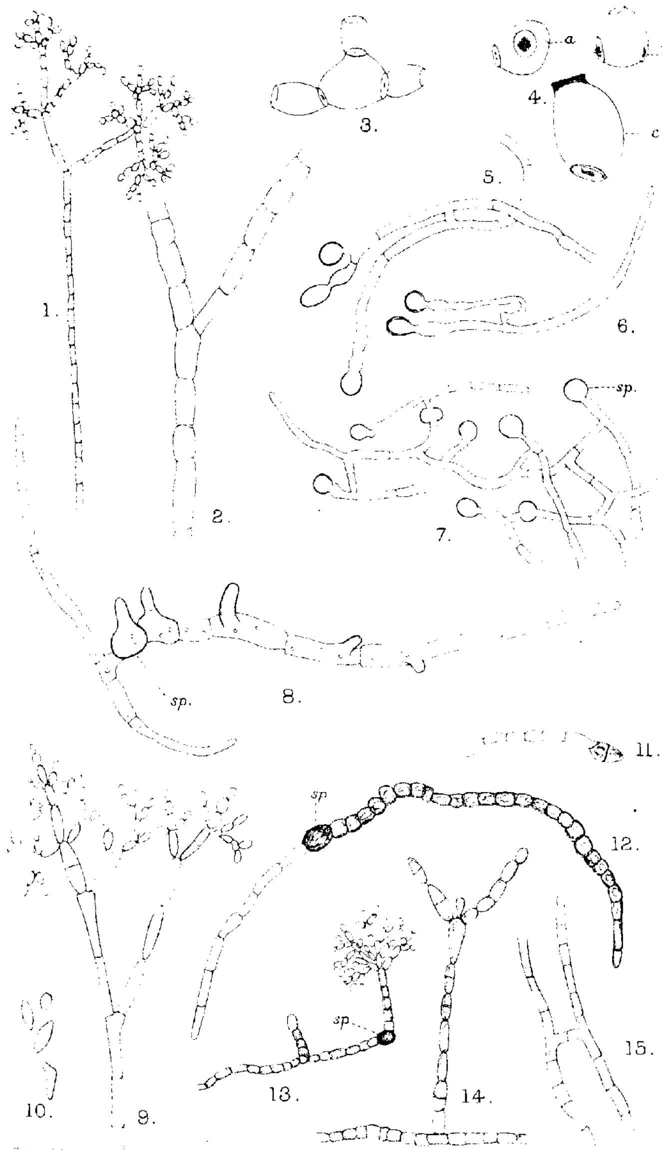
Illustrating Mr. W. B. Grove's paper on "Four Little-Known British Fungi."

Plate III.

Mucor spinosus.

Fig. 1.—Sporangiophore showing both modes of branching, × 150; *a, b, c, d, e,* the order of formation of the sporangia.
Fig. 2.—A very spinose columella, × 600.
Fig. 3.—Various forms of columella from fig. 1, × 400.
Fig. 4.—*M. spinosus*, var. *recurvus*, × 300.
Fig. 5.—Racemose form of *M. spinosus*, × 250.
Fig. 6.—Young sporangium emptied by pressure, × 500.
Fig. 7.—Spores, × 500.
Fig. 8.—Chlamydospores (two germinating), × 300.
Fig. 9.—Ferment-cells, × 300.


1.
a
b
c
d
e
2.
3.
a
b
c
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
a
b
W. B. G. del.
Huth Lith. London.


1.
2.
3.
4.
a
b
c
5.
6.
7.
sp.
8.
sp.
9.
10.
11.
12.
sp
13.
sp.
14.
15.

Rhopalocystis nigra.

Fig. 10.—Conidiophore (dry), × 30.
Fig. 11.—Head with immature basidia, × 80.
Fig. 12.—Head of mature conidiophore, with basidia and sterigmata, × 100.
Fig. 13.—Basidium, with sterigmata and chains of conidia, × 400.
Fig. 14.—Chains of conidia, showing the two forms of isthmus, × 500.
Fig. 15.—Mature conidium, × 1200.
Fig. 16.—Sterigma and newly formed conidia, × 900; *a*, the sterigma; *b*, the conidium just being formed.

Plate IV.

Monilia lupuli.

Fig. 1.—Conidiophore and chains of conidia, × 100.
Fig. 2.—Mode of branching of conidiophore, × 600.
Fig. 3.—Mode of branching of conidial chains, × 600.
Fig. 4.—Separate conidia, swollen in water, × 600.
Fig. 5.—Anastomosis and H-connection of germinating conidia, × 500.
Fig. 6.—Attraction of one germ-tube by another, × 500.
Fig. 7.—A network of germinating conidia (*sp.*), × 500.
Fig. 8.—A germinating conidium (*sp.*), × 600.

Hormodendron cladosporoides.

Fig. 9.—Conidiophore and chains of conidia, × 600.
Fig. 10.—Conidia, × 750.
Fig. 11.—A hyphal joint emitting a mycelial thread, × 600.
Fig. 12.—A conidium (*sp.*) emitting two germ tubes, one olive-coloured, the other pale-grey, × 600.
Fig. 13.—A germinating conidium (*sp.*) which has produced a conidiophore directly, × 300.
Fig. 14.—A conidiophore which has not yet produced conidia, × 500.
Fig. 15.—H-connection of the mycelial hyphae, × 500.

THE TRAINING OF AN ECONOMIC ENTOMOLOGIST.[1]

BY

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IN a recent issue of this Journal, Professor Hickson discusses the place of economic Zoology in a modern University and the best way of training students. I do not wish to discuss the former, but I would like to offer some observations on the training of the student who aims to "*deal with the problems of economic zoology* (entomology) *in a practical manner,*" *i.e.*, become an economic entomologist.

My object is to put down what eleven years practical work as an economic entomologist in the tropics has taught me should be the equipment of a man who takes up this work. Having also trained a number of entomological assistants with Indian University degrees and directed their work, I can perhaps view it from the teacher's as from the student's point of view.

There are at present a number of men working in different parts of the British Empire as "economic entomologists," mainly attached to agricultural departments, but who have as a rule to tackle every sort of problem that comes up, and the problems cover almost every aspect of entomology. Mainly, their work is the study and checking of crop-pests; starting work in a new country as so many have done in recent years, this entails also the building up of collections and records and, for teaching purposes, one must have a big collection and be prepared to give a good deal of time to general entomology. But the root idea is to study crop pests, to work out their life histories, habits, distribution, enemies, etc., with a view to recommending remedies or starting a campaign to check them.

There comes also daily a heap of letters asking advice; a lady wants a remedy for cockroaches; another has an insect, not a bed bug of course, but which bites you in bed; a farmer has a "worm" eating his crops; an intelligent farmer (or planter) has found there is a fortune in silk-worms and wants advice; another has been advised

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that the "Mort Insect" kills every form of pest and wants to know will it kill the aphids on his chrysanthemums. The maker of "Mort Insect" is probably wanting a testimonial, and ten others are offering much better insecticides and want them tested.

If the economic entomologist holds an official position, his Government is probably demanding a scheme for exterminating insect pests by fumigating plant imports, or he is already, *ex officio*, chief inspector of plant imports; they are also demanding publications, perhaps a contribution to a volume on "Nature Study" for school teachers; certainly an illustrated Annual Report, articles for the Agricultural Journal, and eventually a book; collections for museums, exhibits for shows and exhibitions must be forthcoming; he must know all about every insect that strikes the eye of the high official or his wife, and be able to discourse learnedly; he must be a feature of the local Natural History Society. He must be a Court of Appeal in legal cases involving damage by insects, and his duties range from telling how to check fleas on a pet dog to drafting an "Act for the Extermination of Parasitic Insects on Domesticated Animals," and administering the said Act. He may of course be connected with industries such as silk, and have to suppress the enthusiast who thinks you can grow silk on prickly pears in the desert or some equally hopeless place, without having the experience of silk that gives him the means of suppressing the enthusiast. Not quite so bad, but still bad, is the rôle of silk expert—where silk is grown, and where a whole extra branch is added to your duties. There is only one worse thing possible, and that is to require scientific, practical, and trade knowledge *also* of lac, dyes, honey, blister-beetles, and other insect-industries as in India.

I pass that by as I imagine no other country can offer such a complexity of subjects of such a vast economic importance, and of such inherent difficulties as India does: a people of 300 millions and 100 races, an area cultivated of 250 million acres, problems of crops, grain, cattle, disease-carriers, silk, lac, honey, insects used as medicine, as food, as ornaments, as dyes, as hair-washes, and a people mainly inherently brought up not to take life, and you have what, I imagine, is the most varied day's work possible.

With all this, one has to fit in the enquiry and research on which progress is made, and this enquiry should form the bulk of one's work, though there is often very little time to give to it.

The most important class of work that lies before the economic entomologist as a rule is the careful study of each individual species from every point that is likely to bear upon ultimately checking it; its life-history in very full detail, its seasonal occurrence, its food

plants, its peculiar habits, etc., its distribution, its parasites, its periodical occurrence as a pest—these have all to be very minutely known, and any one particular point may require very elaborate working out, as remedies and preventives suggest themselves. Probably every economic entomologist, starting work in a new country or able to give his time to what he pleased, would consider this careful working out of one or a few species at a time as the groundwork of economic entomology and undoubtedly all real progress has come from this class of work.

To do this, to do also all the miscellaneous work that comes to hand, what training is required and what mental equipment will fit the economic entomologist for his work?

I may deal very briefly with the training up to the graduate stage; it requires the general scientific training such as would secure an honours degree, zoology, botany, and chemistry being the three subjects a Cambridge student would take, the last being a minor subject; the average student finds this quite sufficient, and I would not attempt entomology specially until the third year, or preferably do it wholly as a post-graduate course. For a student who definitely had economic zoology in view, field entomology throughout this undergraduate period would be advisable, this being guided by an entomologist. This is not essential, and where it can be done the agricultural training should be got during this period, even if the honours degree were not so high a one in consequence.

As regards the post-graduate course, the first essential is a good general course of entomology, based on a wide knowledge of zoology such as is obtained in the usual zoology course of a University; with this a knowledge specially of field zoology, such as will not help towards a degree perhaps, but for which the worker must have aptitude and gain experience.

The second is a close study of one species in all detail possible, exclusive of its embryonic development and bearing more on its habits and outer morphology than on the histology of its tissues, though not totally neglecting that aspect. I would treat that by trying to refer every detail of the outer anatomy to the habits, not simply describing the structures, but referring them one by one to their function; this is generally neglected, but it is the point of view that is essential.

The third requisite in the training is the close study of one group from the systematic side, solely with a view to getting experience in the distinction of one species from another. It is, in my opinion, wrong for an economic entomologist to continue systematic work

on any group, however important and necessary such work is, as there are so many others doing it and so much other work for the economic worker, but it is essential as a part of training, and if the systematic work done is on a group of economic importance, all the better; but it must be recognised as being only a part of training and not an end in itself.

A close knowledge is required, derived from literature and partly from field work, of economically important species, both of one country and of the world generally. This sounds a large undertaking, but is less so than it sounds; in no country are there more than a definite number of species that really count, that is, that do large and widespread damage; and for the world as a whole, these fall into a few classes which are easily grasped. This implies a knowledge of literature, which is essential; the literature of the ordinary systematic entomologist is not that of the economic worker, and there is no system of recording economic literature such as the Zoological Record. A new species is most carefully recorded in several publications; new facts on economic entomology have not any universal recorder, and the literature is not easy to come by always. A special knowledge of insecticides and machines is required, as also of fumigation and fumigants. This is, I imagine, a long way out of the routine of University instruction, and I imagine the average Zoological department of an University have not even heard of kerosene emulsion; but this is a necessary part of the instruction to be given.

Leaving the purely entomological training, there are two other points of the very greatest importance; they are agriculture and botany. The first thing an agricultural entomologist has to do is to study, not his insects, but the crops. If I were starting again in a new country, as I have twice done, I would, if I could, study the agriculture and the people for some time before I began on the insects at all. An entomologist under training should have a short agricultural training either before or after he does his entomology. He must also have a fair knowledge of botany, not with the aim of identifying his plants, but in view of recognising closely allied plants, of being able to get a general knowledge of the flora which will help when he is seeking out wild food plants allied to crops, and of understanding how plants suffer from pests. Both the agriculture and botany should be done before the entomological course itself starts. These are of course requisites only for the agricultural entomologist, and not required for the veterinary or sanitary officer whose own subject takes the place of agriculture and botany above.

A general economic entomologist such as Governments employ

wants an all-round knowledge also of sericulture, lac, bee-keeping, and the minor insect industries, in case an opening ever offers for starting an industry; nothing brings an entomologist more closely into touch with the public than a minor industry, as it is a tangible money-making thing, whereas his usual work is intangible, preventive and educative work, not visibly directly money-making. It is not every country that has the insect-industries of India, but it has often struck me that India would not still have a monopoly of lac cultivation if economic entomologists generally understood anything about it. If England did go in for the energetic American methods, our Universities would have entomologists who knew what lac was and had seen it growing; but we have not, and the result is that our Colonies recruit their entomologists from America.

It is not necessary, of course, for an economic entomologist who is going, say, to Uganda, to know sericulture in all its details, but he should know generally about it, what cocoons are of value, how they are grown or collected, used and sold, and be able to get a valuation for any wild cocoons he might come across. I do not think the average University includes on its staff anyone capable of helping the student in that.

There are a few points left which will help when one is starting new work. One is a little training in methods of producing and printing illustrations. This is a very important part of work, and without some technical knowledge one is terribly handicapped. A short course of instruction in this is really a necessity.

Another is a training in technical methods of setting, preserving collections, making up show cases, etc. I would add to it a training in office methods, in methods of recording information, and in such methods as card-indexing. Each worker, of course, develops his own methods, but a small amount of training in methods is extremely useful. The last I can think of, and not the least, is some amount of literary training. A fluent pen is a great boon to an economic entomologist, both in letter writing and in writing bulletins, leaflets, etc. For eight years I have written daily for at least an hour, often two or more, when my work was over for the day, simply to get and keep my pen fluent, and I think every economic entomologist in training should deliberately cultivate his literary faculties, especially in the "popular article" direction.

This closes my sketch of the training required, except that I have not sufficiently emphasised the "atmosphere" of the general training in entomology. I would dissociate this training entirely from the general zoological training, doing it as a post-graduate course; the trend of the course must not be that of the comparative

anatomist, the evolutionist, the systematist, or the histologist; embryology does not come into it, nor does field entomology in the general sense. The atmosphere is difficult to realise because the word "economic" in this connection means so little to some people; but it is perhaps best expressed in this way; if a systematist picked up an insect on the road he would regard it as a beetle, sub-order so and so, family so and so, division, etc., and would probably, if interested in beetles, be able to name it and then care no more; that attitude we do not want; the general zoologist would regard it as an insect, perhaps a beetle, and then drop it; the comparative anatomist would pick it up, wonder how many and what sort of egg tubes it had, wish he had time to tackle it and drop it; a few entomologists would pick it up, wonder where it came from, what it was doing there and so on; the man we want would do that and also think of its place in nature as regards man, if it was predaceous or herbivorous, if it did damage, of its allies and their place, and of how one would tackle a large increase in their number. To that view, a working knowledge of embryology, other than as gained in a very general zoological course, would not be of the least use, and the difficulty in making economic zoologists in England will be the preponderance of the Academic view and the total absence of the economic view based on experience. Economic entomology is not taken seriously in England, not as it is in America or the Colonies; I do not know about economic zoology as regard fisheries and such industries; but I do think English Universities have a very long way to go before they can turn out entomologists of the practical stamp that America does.

Field entomologists who study the living insect are rare enough; of these a very small percentage have that rare addition of "applied common sense"; and if that rare combination has appeared, there is not a University that can give him the practical economic training.

I have happened to have a good deal to do also with medical entomology, and the lack of knowledge of entomology of the medical men who have to apply themselves to entomological problems is very painful; but we realise that there are very few places in England where medical men can get their training, and even then the training seems to lack a great deal. I came across a series of experiments being done with hydrocyanic acid in a prominent bacteriological laboratory once, and the trained investigators, working on an entomological problem, were wholly ignorant of the use of cyanide as a fumigant and of the literature there is on its use. In another case, oil was being used as an

insecticide and was abandoned as it was messy, the investigator regretting it was not an emulsion; yet crude oil emulsions are generally known, outside England, as insecticides, only these investigators happened to be English and had never heard of it.

Professor Hickson points out quite rightly that even if an University can give training in agricultural pests, it cannot do so in forest pests; let me state at once that the last thing a student wants is detailed knowledge of the pests he is to fight. No man will ever do good unless he studies the matter afresh for himself and then reads up what his predecessors have done or others have done.

The only useful piece of knowledge that can be taught to a man is how to recognise the stages, what the group generally does, and, if possible, to recognise the most important pests of the world in their imago stage. To give a student field experience of the pests he is to fight is absolutely fatal; if he is to do any good he will study his pest *de novo* and then read afterwards what others have written. If he has not grit enough to take on the investigation of new pests under new surroundings, he will never be any good, and if I were training a man for India, I would never teach him more than methods, certainly not cram him up in what was known of Indian pests. The real things that matter in agricultural entomology are (1) the local agricultural practices, (2) the people and their resources, (3) the pest. So I would have a worker tackle the first two first and the pest last, but the last he should tackle with a first-rate all-round general training. This kind of training can be given anywhere, but I fail to see how any University can give it at present or how the demand for men in the Colonies is to be met by Universities staffed by men who never leave England. Out in the Colonies, one is directly up against large problems requiring practical solutions, suited to ordinary folk; with all due respect to our Universities, from one of which I went to this work, the atmosphere is too "academic," and this atmosphere is reflected in the article of Professor Hickson.

Throughout this article I am thinking of the entomologist who will be working outside England, and it may be thought that the training I have outlined is an impossibly wide one; I may point out that in our Colonies, one has to be "self-sufficing" to a very large extent; one cannot always get help, or go round the corner and consult a botanist or a chemist, or visit museums, libraries, etc. The facilities of civilization are often conspicuous by their absence; one may be working for or with the people whose standard of life does not include any metal or woodwork, whose vessels do not go beyond pottery and basket work. Nor can we get a "Pest Act"

passed and enforce it always on uneducated agricultural peoples. I imagine that many an English entomologist or zoologist put down in a far country to tackle one of the big problems would be very much surprised indeed, and that the deeper he went the worse it would get. So that, if my training seems wide, it must be remembered that it covers the knowledge I have wanted or found useful and that, except in entomology and the local agriculture, it need not be very profound. An agricultural entomologist wants a working knowledge only of botany and chemistry, he cannot also be a botanist and chemist, but he must understand how to utilise them and how to bring his difficulties to the botanist and chemist eventually.

Finally, it may happen that this article may be read by prospective candidates for posts as economic entomologists. Let me remark therefore that the life of an economic entomologist is not a pleasant daily round of entomology and investigation; the investigation is much of it done in spare time; the publication of learned papers drops, in favour of publishing bulletins for the public; to deal with the letters from the public, whose servants you are, is not easy unless you prepare a stock of leaflets on every subject and answer by that means. The life of an economic entomologist is that of any busy business man, if his work is any good to the public, and the quiet necessary to research and enquiry is not to be found in it. This too applies not only to one's work at "headquarters"; one's work in the field is of a very unacademic and rough kind, which makes demands more on the body than on the mind. Of course there are many who regard the public as an enemy and that, at all costs, research is to be carried on; those persons should be in the places provided for research—universities—and not in government service. If economic entomology is ever to have a practical meaning, and is to do its share in agriculture, medicine, sanitation, and other practical things, the economic entomologist has got to be there, putting forth his practical knowledge and not be shut up in a deep research. In the ideal state, entomologists will, of course, abound, and while one researches, another will write, another classify and so on; in our imperfect civilisation, the one man must do all, and if the subject is to go forward, he must be trained to do it in a business way with the least waste of time, and must, as things now are, aim at making himself felt by the public so that the value and need of scientific inquiry may be realised.

We are on the threshold of greater things, and to whatever problem comes, one must put one's hand. Only so is the practical entomologist going to convince an unlearned public and sceptical

governments that there is anything at all in it, and we are, in England certainly, beginners who must look to the future. England should be the source at least of the entomologists of her Empire, but she is not, and unless radical changes take place in the atmosphere of her teachers, she will *not* be. The training will have to be that of practical field entomologists if the demand is to be met from England, and the last thing it wants to be is the academic zoological training of the average English University.

REVIEWS.

Jörgensen, A.—Micro-Organisms and Fermentation. Trans. by S. H. Davis. 4th ed. Pp. xi + 489, 101 figs. London: Charles Griffin and Co., Ltd., 1911. Price 15/- net.

This is the fourth English edition of Jörgensen's well-known text-book, a fact which in itself indicates the esteem in which it is held in this country.

A considerable amount of new matter has been incorporated and many alterations have been made, so that we may really regard the book as a new one.

The plan followed is as of old. There is an excellent introduction, followed by the consideration of the biological examination of air and water, and chapters on bacteria, moulds, yeasts, and the pure culture of yeast on a large scale. A copious bibliography and index compile the work.

The thoroughly practical nature of the book and the lucid yet concise manner in which it is written, fully entitles it to be still regarded as a standard work on the subject.

Lundbeck, W.—Diptera Danica Genera and Species of Flies hitherto found in Denmark. Pt. III. *Empididae.* Pp. 324, 141 figs. Copenhagen: G. E. C. Gad. 1910.

In referring to the previous parts of Professor Lundbeck's monograph, we spoke in highly appreciative terms of the scope and style of this valuable work, and the third part now before us fully merits all we then said.

The same care has been expended upon the descriptions of genera and species, and numerous notes on the habitat of the larvae and habits of the imagines are recorded.

The developmental stages of the Family are only imperfectly known, as in many other families of the Diptera.

About 675 species are known from the palaearctic region, of which 164 are described in the volume before us; many of these are illustrated by excellent text-figures showing the wings, antennae, legs, genitalia, etc.

The work bids fair to become one of the leading monographs, and we trust it will receive the support of all British dipterologists.

W. E. C.

Willey, A.—Convergence in Evolution. Pp. xv + 177, 12 figs. London: John Murray, 1911. Price 7/6 net.

This work, so the author informs us, may be regarded as an attempt at a reply to Dr. Gaskell's remarkable work on the "Origin of Vertebrates."

The term "convergence" is not a happy one if indeed it is better than the old one of "parallel evolution," it would therefore perhaps be better to adhere to Lankester's term "homoplassy."

Although biologists have been, and many still are, loath to admit that there are many instances of similarity of form which have no connection in regard to inheritance, the cases daily becoming more numerous, and we regret that the author of the work before us has not given more illustrations of this kind. Interesting as his work is, his exposition is by no means clear, yet biologists will welcome a work in which convergence is dealt with as a general and positive phenomenon of equal importance with orthogenesis or normal morphology.

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We have to thank Dr. Hopkins for a further excellent monograph on economic entomology. Beyond stating that the high standard set in his previous works is fully maintained we need not comment upon it.

It is a great pity that better paper has not been used for the plates.

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